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(71) Applicant(s)
Motorola Limited
(Incorporated in the United Kingdom)
European Intellectual Property Operation, Jays Close,
Viabes Industrial Estate, BASINGSTOKE, Hampshire,
RG22 4PD, United Kingdom

(72) Inventor(s)
Rong Shi

(74) Agent and/or Address for Service
Peter D Hudson
Motorola Limited, European Intellectual Property
Department, Midpoint, Alencon Link, BASINGSTOKE,
Hampshire, RG21 7PL, United Kingdom

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(54) Abstract Title
Packet routing to a mobile station

(57) Data to be transmitted from a source 30 to a mobile station 42 is routed via internet nodes 2, 4, 10, 16, 12, 14, 20 to an internet router 26 which also serves as a gateway from the internet to the first cellular communication network 40. In the event of the mobile station moving from the first network to a second network 50 during data transmission, the route is extended to reach the second network. If a fall in the quality of service is observed using the extended route, a replacement packet switching route 2, 8, 22 is put into place.

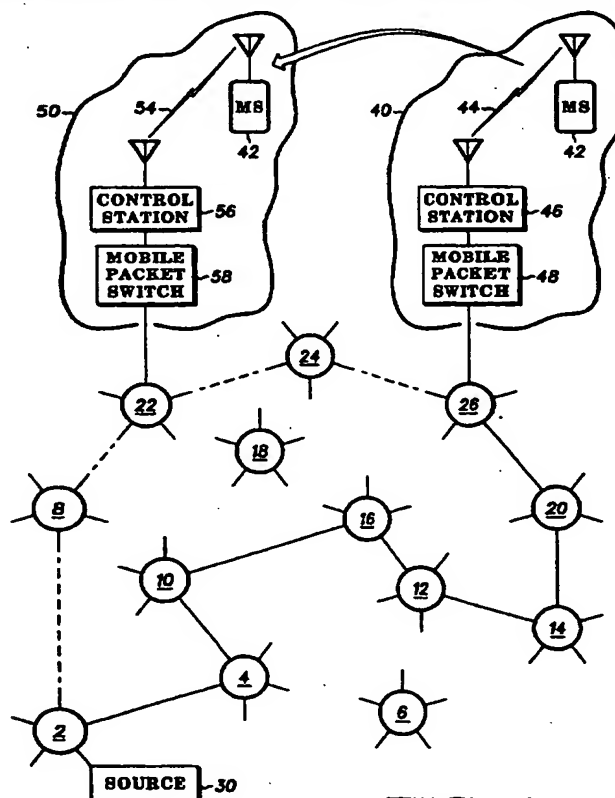
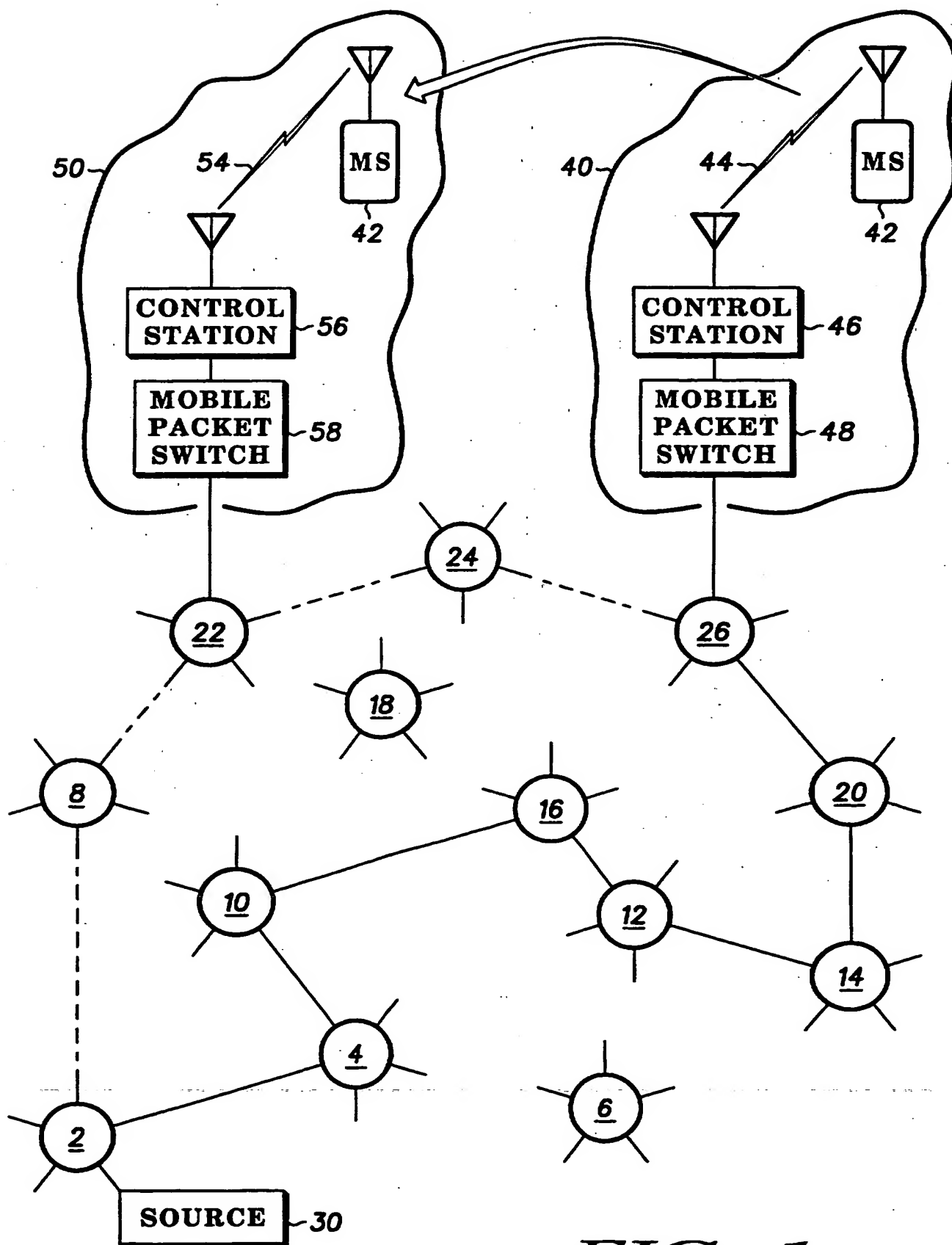
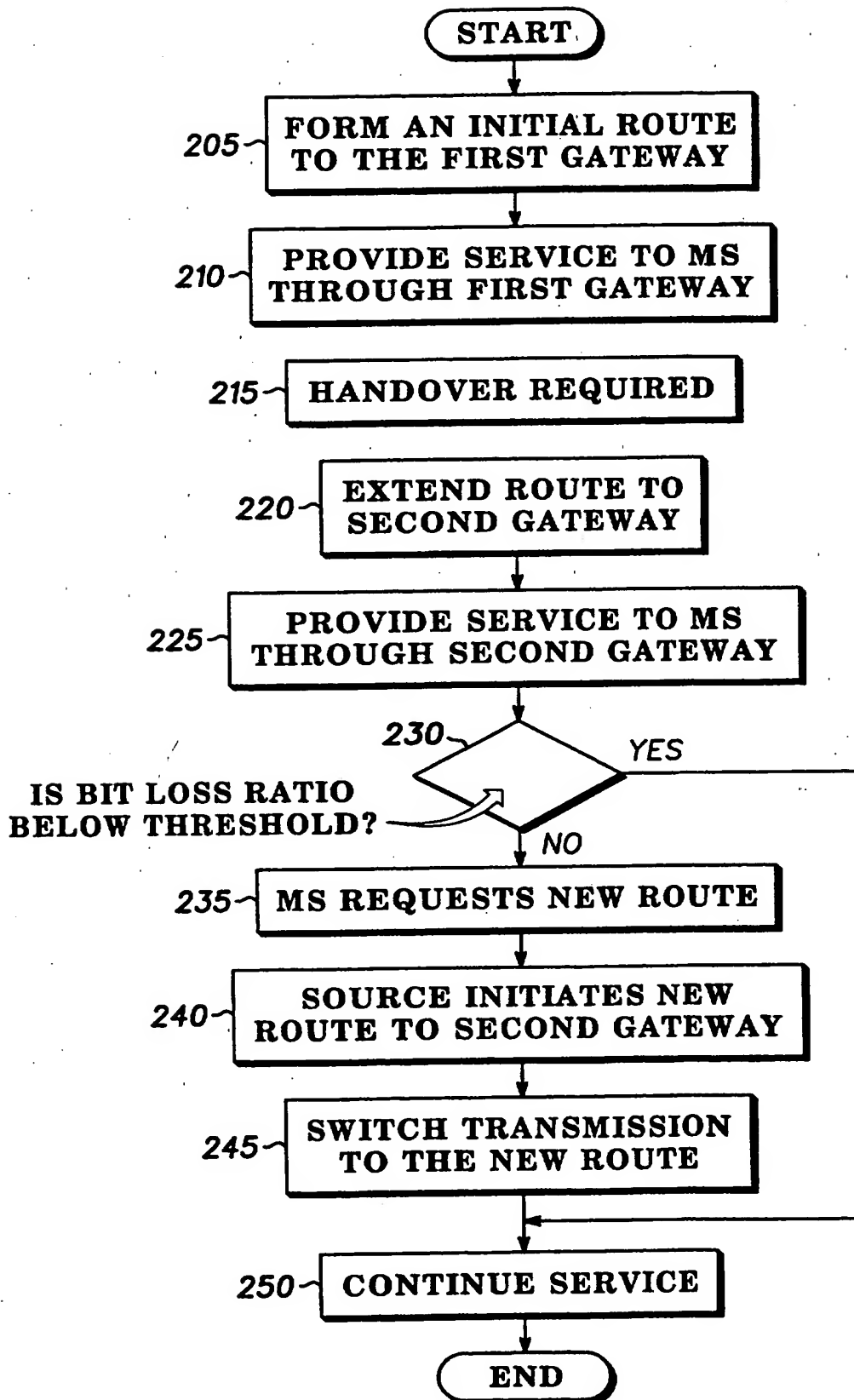


FIG. 1

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

**FIG. 1**

**FIG. 2**

PACKET ROUTING TO A MOBILE STATIONFIELD OF THE INVENTION

The present invention relates to a method of, and apparatus for, routing to a mobile station in a packet switched network arrangement. The present invention is applicable to, but not limited to, cellular communications systems such as the Universal Mobile Telecommunication System (UMTS) currently under standardisation.

10

BACKGROUND OF THE INVENTION

One type of communications system is a cellular communications system. In a cellular communications system, the area over which service is provided is divided into a number of smaller areas called cells. Typically, each cell is served from a base transceiver station (BTS) which has a corresponding antenna or antennas for transmission to and reception from a user station, normally a mobile station. An established harmonised system cellular radio communication system is GSM (Global System for Mobile Communications). A further harmonised system currently being defined is the universal mobile telecommunication system (UMTS), which is intended to provide a harmonised standard under which cellular radio communications networks and systems will provide enhanced levels of interfacing and compatibility with other types of communications systems and networks.

In addition to speech and data services, increased provision of multimedia communications will be provided for. It is also expected that within the framework of developments such as UMTS or the like, cellular radio communication systems will increasingly interface with information networks such as the Internet.

Public data networks or information networks such as the Internet operate by the well known method of packet switching. Information to be transmitted across the Internet is packetized. The Internet consists of many nodes or Internet routers. A packet switching route is established between a source node and a destination node. Various methods of determining the routes are known. One method is called hop-by-hop routing. This is a dynamic method in which each Internet router makes its own decision about which next router to send the route forming details to where the route details can be in the form of a datagram. Another known method is source routing. Under source routing the route is selected by the source node for a certain data stream. In networks employing datagrams, some or all of the route from source to destination is explicitly stated in the datagrams. Both hop-by-hop and source routing are implemented in, for example, the Internet Protocol (IP). Two forms of source routing are used in IP networks. The first is strict source routing. Under strict source routing, a sender specifies the exact path that an IP datagram must

follow. If an Internet router encounters as a next hop in the source route, a node that is not on the specified route, an ICMP (Internet Control Message Protocol) source route failed area message is returned. The second form
5 is loose source routing. Under loose source routing the sender specifies a list of IP addresses that a datagram must traverse, but the datagram can also pass through other Internet routers between any two addresses in the list.

10 A cellular communications network can interface with a packet switched network arrangement such as the Internet via an Internet router serving as a gateway to the cellular communications network. Thus, when information is to be communicated to a mobile station in
15 a cellular communications network or system, the route is established to the appropriate Internet router serving as the gateway of the cellular communications network.

The interaction between a mobile station in a cellular communications network and a general packet
20 switched network arrangement, as described above, creates a broad range of new engineering problems and challenges.

One challenge is to consider whether previously known methods of performing the routing within the packet switched network arrangements, such as the Internet, can
25 be advantageously replaced or modified in the light of the different operating factors introduced by the mobility of a user of a mobile station in a cellular

communications system.

SUMMARY OF THE INVENTION

5 In the light of the above, the present inventor has envisaged how routing in a packet switched network arrangement can be handled when the movement of a mobile station during receipt of information leads to the service being handed over from a first gateway to a
10 second gateway. In particular the present inventor has envisaged that it would be advantageous to involve aspects of quality of service (QoS) within such cellular communications networks which may be affected by routing requirements introduced by the handover between gateways.
15 Some examples of quality of service parameters that can be of significance in cellular communications are delay, jitter, bit loss ratio and bit error rate.

 According to a first aspect of the present invention, there is provided a method of routing to a
20 mobile station in a packet switched network arrangement.

 An initial packet switching route provided to a first cellular communications network in which a mobile station is receiving service is extended, in the event that handover of service to a second cellular communications
25 network requires a change in the route, thereby forming an extended packet switching route, and thereafter, dependent on a level of quality of service determined for

the extended route, a new packet switching route is formed to the mobile station. The various packet switching routes are established to packet switching nodes serving as gateways to the respective cellular communications networks. The different cellular communications networks are served via different gateways.

One or both of the cellular communications arrangements served by different gateways can be a UMTS network.

The various routes are formed from a source in a packet data network forming part of the packet switched network arrangement. The packet data network can comprise an information network such as the Internet.

The quality of service parameter can be additive over the various routes. This is particularly relevant when it is additive over the extended route. The quality of service parameter can comprise delay, jitter, bit loss ratio or bit error rate. Alternatively, a quality of service parameter can comprise a function of two or more of the above-mentioned parameters.

An achieved or measured level of quality of service can be compared to a threshold, and if the quality of service achieved on the extended route is below the threshold, the new replacement route is formed. The threshold can vary according to the type of data being transmitted or provided by the source.

The initial route can be formed by any appropriate routing method, including hop-by-hop routing, strict source routing and loose source routing.

5 The determination of the quality of service can be performed by the mobile station or by a network management entity. Similarly the decision to form a new route can be determined by the mobile station or a network management entity.

10 According to another aspect of the invention, there is provided an apparatus for carrying out routing to a mobile station in a packet switched network arrangement.

The apparatus comprises means for forming an initial packet switching route to a first cellular communications gateway providing the service to a mobile station, means
15 for extending, in response to the first cellular communications gateway handing over service to a second cellular communications gateway, the initial route thereby forming an extended packet switching route, and means for forming, dependent on the quality of service,
20 a new packet switching route to the second cellular communications gateway to replace the extended route.

The extension to the initial route, and the entirely new replacement route, can each in themselves be formed by any appropriate route forming method, including
25 hop-by-hop routing, strict source routing and loose source routing.

According to yet another aspect of the invention,

there is provided a storage medium storing processor implementable instructions for controlling a processor to carry out any of the above described methods.

According to yet another aspect of the invention,
5 there is provided a signal carrying processor implementable instructions for controlling a processor to carry out any of the above methods.

According to yet another aspect of the present invention, there is provided a cellular communications
10 mobile station with means for analysing or determining a quality of service it is receiving when it is receiving that service through an extended communications route due to movement, and means for requesting a new communication route if that quality of service is insufficient.

15 The present invention advantageously retains a routing connection in a simple fashion when handover is required, yet then allows satisfactory quality of service to be maintained thereafter. Furthermore, the present invention avoids wasteful use of resources employed in
20 establishing a new route, if the extended route is sufficient in terms of quality of service. The present invention is particularly advantageous in coping with additive quality of service parameters.

Additional specific advantages are apparent from
25 the following description and figures.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is an illustration of a packet switched network arrangement in accordance with the present invention.

Figure 2 is a process flow chart of an embodiment
5 of the present invention.

DESCRIPTION OF AN EMBODIMENT OF THE INVENTION

One particular embodiment of the invention is now described by way of example only. Figure 1 shows, in the
10 form of a schematic illustration, nodes 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26 of a packet data network.

In the present embodiment the packet data network is the Internet and the nodes are each Internet routers. In practice the Internet contains many more nodes than those
15 shown in Figure 1 by way of example.

A source 30 is coupled to Internet router 2. Packetized data being output by a source 30 is input into the Internet via node 2 for onward transmission to a specified destination. In the present embodiment source
20 30 is a work station operated by a provider of information services such as route maps, news reports and so on which can be in multimedia form. Source 30 can alternatively be any other source of data to be transmitted across the Internet.

25 In the present embodiment the destination for the information is any suitable mobile station (MS) 42, which in the present case is a mobile telephone. MS 42 is

originally located in the geographical service area of a first cellular communications network 40. Also shown is a control station 46 of the first cellular communications network 40. In the present example the control station
5 consists of a base station system (BSS), which itself incorporates a base station controller (BSC) and a base transceiver station (BTS). A communication link 44 is established between MS 42 and control station 46, and is in the form of a radio link. The particular geographical
10 area served by control station 46 constitutes one cell of the first cellular communications network 40.

Control station 46 is coupled to mobile packet switch 48. In the present embodiment the first cellular communications network 40 only comprises a single mobile
15 packet switch 48. Further control stations can be coupled to mobile packet switch 48, but these are not shown in Figure 1.

In the present embodiment mobile packet switch 48 is coupled to Internet router 26. Internet router 26
20 serves as a gateway from the Internet to the first cellular communications network 40. Thus when the source 30 specifies MS 42 as the destination of data, that data will need to be routed through various Internet routers ending at Internet router 26.

25 Figure 1 also shows a second cellular communications network 50. As will be described in further detail below, the operation of the present

embodiment will be described for the situation when MS 42 moves from the first cellular communications network 40 to the second cellular communications network 50. The second cellular communications network 50 comprises a control station 56, and a mobile packet switch 58, both of the same sort as contained in the first cellular communications network 40. When MS 42 is served by the second cellular communications network 50, such service is provided via a communications link 54 which is in the form of a radio link. As was the case with the first cellular communications network, in the second cellular communications network 50 there can be further control stations connected to the mobile packet switch 58, although not shown in the figure, but mobile packet switch 58 is the only mobile packet switch in the network.

Mobile packet switch 58 is coupled to Internet router 22 which serves as a gateway to the second cellular communications network. Thus when MS 42 is handed over from the first cellular communications network 40 to the second cellular communications network 50, the route through the Internet will need to be changed so as to end at Internet router 22 instead of Internet router 26.

The processing steps involved in the present embodiment will now be described with reference to the process flow chart of Figure 2. Function box 205 shows

the step of forming an initial route from the Internet router 2 to the Internet router 26 serving as a gateway.

This is performed in response to a requirement for source 30 to send packetized data to MS 42. The initial
5 route is formed or established by any suitable means. In the present case a conventional Internet protocol (IP) procedure is employed. More particularly, a hop-by-hop routing method is employed. Internet router 2 forms a suitable datagram for hop-by-hop routing, and thereafter
10 the route is established in a conventional hop-by-hop manner with each router choosing an appropriate next router according to the datagram and based on the available next routers' situations. In the present case such a route is formed as shown in Figure 1 in bold and
15 consisting of Internet routers 2, 4, 10, 16, 12, 14, 20 and ending, as required, at Internet router 26.

The initial route can alternatively be formed by source routing. Under this procedure the overall route will be determined to a greater or lesser extent by the
20 source node i.e. Internet router 2. In this case Internet router 2 forms datagrams including details of the route, and these datagrams can be included for example in each IP packet header. Two forms of source routing are possible in the IP network. The first is
25 strict source routing, in which Internet router 2 specifies the exact path that the IP datagram must follow. When the route is formed for packets covered by

the IP datagram, only specified next Internet routers are connected, and when instead any other Internet routers are encountered an Internet control message protocol (ICMP) source route found error message is returned to

5 the previous Internet router. In a second type of source routing, called loose source routing, Internet router 2 includes in the datagram a list of Internet routers that the datagram must traverse, the datagram can also pass through other Internet routers between any two addresses

10 in the list. Thereafter cellular communication service is provided to MS 42 via radio link 44 established between the control station 46 and the MS 42. As shown by function box 210, the packetized data is transmitted over the initial route to Internet router 26 (serving as

15 gateway) and through mobile packet switch 48, control station 46 and radio link 44 to MS 42. In the present embodiment MS 42 does not monitor the quality of service whilst transmission takes place over the above described initial route. The suitability of such an approach will

20 depend upon the details of the arrangement under consideration. In the present case, for example, MS 42 has previously established that requesting such items of information, as are being delivered in the present embodiment, consistently provides a satisfactory quality

25 of service level so long as the MS remains in the first cellular communications network 40. In other examples, however, MS 42 may at the stage of receiving data over

the initial packet switching route assess the level of quality of service it is receiving and request alternative routes dependent upon those levels.

When MS 42 moves within the first cellular communications network 40 such that it only requires to be handed over to a different cell of that system, (i.e. an area served via a different control station other than control station 46), then no change to the Internet routing is involved because the gateway from the Internet route to the first cellular communications network remains as the gateway provided by Internet router 26.

However, when MS 42 moves such that handover to the second cellular communications network becomes required, the following procedure is employed. On determination that handover is required to the second cellular communications network 50, as shown at function box 215, this information is conveyed from mobile packet switch 48 to Internet router 26, in the form of an indication that the route now needs to reach Internet router 22.

Consequently, as shown at function box 220, the IP datagrams are updated and the initial packet switching route is extended in hop-by-hop fashion in the present example to Internet router 24 and then Internet router 22, as shown by long dashed lines in Figure 1. Handover can then take place, and, as shown at function box 225, service is resumed in the second cellular communications network 50 through the new gateway 22, mobile packet

switch 58, control station 56 and radio link 54.

MS 42, on determining that handover has taken place, analyses a quality of service parameter. In the present embodiment MS 42 analyses the bit loss ratio over
5 a given period of time. The bit loss ratio is a parameter defining the number of bits that have been lost compared to the overall bits originally contained in the data transmission. Error coding and other suitable signalling data within the data transmission flow is
10 analysed by MS 42 in order to determine the bit loss ratio. In the present embodiment MS 42 is programmed with two separate thresholds of bit loss ratio, a milder threshold of 0.02% and a harsher threshold of 0.01%. MS 42 is further programmed to employ the milder threshold
15 when the data being transmitted does not include video, and the harsher threshold when the data being transmitted does include video. Alternatively a single threshold can be used. In the present example let us assume there is no video included in the data transmission, thus MS 42
20 compares its measured bit loss ratio with the milder threshold, as shown at decision box 230. Provided the measured bit loss ratio is below the threshold the communication service is continued as shown at function box 250. However, if MS 42 determines that the measured
25 bit loss ratio is not below the threshold, then the quality of service provided by the extended route is inadequate, thus MS 42 requests a new route from source

30, as shown at function box 235. This request is made in a conventional manner over a separate route established through the Internet from gateway 22 to Internet router 2.

5 In response to a request from MS 42, source 30 initiates a new route to the Internet router 22, serving as the gateway to the second cellular communications network, as shown at function box 240. In the present embodiment the new route is simply established once again
10 by the hop-by-hop method. In the present example a new route is formed from Internet router 2 to Internet router 8 and thereon to Internet router 22, as shown by dotted lines in Figure 1. Internet router 2 then switches transmission of data to the new route instead of the
15 extended route, i.e. the new route replaces the extended route, as shown at function box 245. Thereafter, as shown at function box 250, service is continued via the new Internet route to Internet router 22. In the above embodiment, since the quality of service parameter
20 consisting of bit loss ratio is additive over consecutive links in the Internet route, then the reduction in quality of service produced by the addition of links to the original route, in the present example taking the quality of service below the required threshold, is
25 overcome by the establishment of a new route which is more appropriate given that the end Internet router has now changed to Internet router 22. In the example shown

in Figure 1, the new route is likely to be better than the initial route to the first gateway (Internet router 26). However, such an improvement over the initial route is not necessary to the invention, rather the new route
5 merely needs to be more appropriate than the extended route.

In the above embodiment the quality of service parameter measured by MS 42 was bit loss ratio over a given period of time. In other embodiments the bit loss
10 ratio could be measured over a given number of data bits.

A further bit related quality of service parameter that can be measured and employed is bit error rate, i.e. the number of bits in error per time unit, which again can be assessed by MS 42 by analysing error coding in the
15 transmitted data stream. Further possible quality of service parameters that can be employed include those related to delay. The total delay of packets from source 30 or Internet router 2 to MS 42 or the respective gateways provided by Internet routers 22 and 26 is
20 additive and includes the propagation delay between the different Internet routers on the route and also packet queueing delay occurring at each Internet router or other node. MS 42 measures and analyses the delay experienced by received packets by further using a special probe
25 message (based on ICMP messages) which is sent by Internet router 2 and which serves to synchronise a timer of the work station used at source 30 and a timer of MS

42. Quality of service parameters derivable from delay characteristic include maximum experienced delay, and jitter, where jitter can be defined either as average delay or as a difference between a maximum and a minimum delay.
5

In the above embodiment a single parameter, namely bit loss ratio was employed. Other alternative single parameters have been described. In further embodiments of the present invention, further quality of service parameters can be defined and employed, including functions of two or more of the above described single parameters. In the above embodiment each of the first and second cellular communication networks are any suitable forms of network. One preferred option is for one or both of the networks to be a UMTS network. Another preferred option is for one or both of the networks to be a general packet radio switch (GPRS) network.
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15

In other embodiments, other forms of public data network other than the Internet can be employed. Similarly, other types of networks such as restricted access networks and private networks can be employed.
20

In the above embodiments the quality of service parameter was determined and measured by the mobile station, and similarly the decision to form a new route was determined by MS 42. In other embodiments these functions can be either shared by or fully performed by entities other than MS 42. In particular a network
25

management entity can carry out these functions. Any suitable network management entity can be employed, for example a control function associated with one of the Internet routers, preferably either Internet router 2 or a gateway providing router such as 22 and 26, but also possibly any Internet router included in an established route. Similarly, source 30 can perform some or all of these functions. Whichever item performs the above functions, they are implemented by one or more processors. The or each processor is implemented in the form of software running on a suitable processor such as a microcontroller or digital signal processor, or is implemented in the form of specifically designed hardware or a combination of hardware and software. The processor can be controlled by processor implementable instructions, for carrying out the method steps described in the above embodiments, which are stored in a storage medium. The storage medium can be a disk, e.g. floppy disk or hard disk, memory such as RAM, or any other appropriate medium. Alternatively, the or each processor can receive the instructions via a signal carrying the processor implementable instructions. In the above main embodiment, the new replacement route from Internet router 2 to Internet router 8 and then on to Internet router 22 was performed by a hop-by-hop routing method. In other embodiments the new route is performed by one of the above described source routing methods in order to

further ensure satisfactory quality of service on the eventually established route. In the above embodiment the quality of service on the originally extended route was compared to a threshold. In other embodiments the
5 quality of service of the extended route can be processed relative to criteria other than a fixed threshold. One possibility is to compare the quality of service of the extended route to the quality of service measured and achieved on the initial route and to only form a new
10 replacement route if the quality of service of the extended route falls below that of the initial route. Another alternative is to only form a new route if the quality of service via the extended route falls below the quality of service of the initial route by a given
15 proportion.

In the above embodiment the first cellular communications network 40 and the second cellular communications network 50 are made up of separate hardware such as the separate control stations and
20 separate mobile packet switches. Their respective geographical service areas overlap such that handover can take place, and this is performed analogously to handover between cells of a single cellular communications network. In other embodiments there are other respective
25 relationships between two items, conveniently termed networks or communication systems. Indeed, the present invention can be applied to any scenario in which a

mobile station initially receives service in one constellation, domain or facet of a cellular communications arrangement employing a first gateway from the packet switched data network, and changes over to a
5 second constellation, domain or facet of a cellular communications arrangement requiring service to be provided via a second gateway from the packet switched data network. Furthermore, the term gateway refers to any suitable interface where a cellular communications
10 arrangement interfaces with the other parts of an overall packet switched network arrangement.

CLAIMS:

1. A method of routing to a mobile station in a packet switched network arrangement, the method comprising the
5 steps of:
 - forming an initial packet switching route to a first cellular communications gateway providing service to a mobile station;
 - extending, in response to the first cellular
10 communications gateway handing over service to a second cellular communications gateway, the initial route to form an extended packet switching route; and
 - forming, responsive to a level of a quality of service parameter achieved over the extended route, a new
15 packet switching route to the second cellular communications gateway to replace the extended route.
2. A method according to claim 1, wherein the different cellular communications gateways serve different
20 cellular communications networks.
3. A method according to claim 2, wherein at least one of the cellular communications is a UMTS network.
4. A method according to any preceding claim, wherein
25 the routes are formed from a source in a packet data network.

5. A method according to claim 4, wherein the packet data network is the Internet.

6. A method according to any preceding claim, wherein
5 the quality of service parameter is additive over the extended route.

7. A method according to claim 6, wherein the quality of service parameter comprises one of the following or a
10 function of a plurality of the following:

- (a) delay;
- (b) jitter;
- (c) bit loss ratio;
- (d) bit error rate.

15

8. A method according to any preceding claim, wherein the achieved level of the quality of service parameter is compared to a threshold to determine the step of forming the new route.

20 9. A method according to claim 8, wherein the threshold varies according to the type of data being communicated or to be communicated over the extended route.

10. A method according to any preceding claim, wherein
25 the initial route and/or the extended route and/or the new route is formed by hop-by-hop routing.

11. A method according to any of claims 1 to 9, wherein the initial route and/or the extended route and/or the new route is formed by source routing.
- 5 12. A method according to any preceding claim, wherein the achieved level of the quality of service parameter is determined and/or a decision to form the new route is determined by a network management entity.
- 10 13. A method according to any preceding claim, wherein the achieved level of the quality of service parameter is determined and/or a decision to form the new route is determined by the mobile station. 14. Apparatus for routing to a mobile station in a packet switched network
- 15 arrangement, the apparatus comprising:
- means for forming an initial packet switching route to a first cellular communications gateway providing service to a mobile station;
- means for extending, in response to the first
- 20 cellular communications gateway handing over service to a second cellular communications gateway, the initial route to form an extended packet switching route; and
- means for forming, responsive to a level of a quality of service parameter achieved over the extended
- 25 route, a new packet switching route to the second cellular communications gateway to replace the extended route.

15. Apparatus according to claim 14, wherein the different cellular communications gateways serve different cellular communications networks.

5

16. Apparatus according to claim 15, wherein at least one of the cellular communications is a UMTS network.

17. Apparatus according to any of claims 14 to 16, wherein the routes are formed from a source in a packet
10 data network.

18. Apparatus according to claim 17, wherein the packet data network is the Internet.

15 19. Apparatus according to any of claims 14 to 18, wherein the quality of service parameter is additive over the extended route.

20. Apparatus according to claim 19, wherein the quality
20 of service parameter comprises one of the following or a function of a plurality of the following:

- (a) delay;
- (b) jitter;
- (c) bit loss ratio;
- 25 (d) bit error rate.

21. Apparatus according to any of claims 14 to 20,

further comprising means for comparing the achieved level of the quality of service parameter to a threshold to determine operation of the means for forming the new route.

5

22. Apparatus according to claim 21, wherein the threshold varies according to the type of data being communicated or to be communicated over the extended route.

10

23. Apparatus according to any of claims 14 to 22, wherein the means for forming the initial route and/or the means for forming the extended route and/or the means for forming the new route is adapted to employ hop-by-hop

15 routing.

24. Apparatus according to any of claims 14 to 22, wherein the means for forming the initial route and/or the means for forming the extended route and/or the means for forming the new route is adapted to employ source

20

routing.

25. A storage medium storing processor-implementable instructions for controlling a processor to carry out the method of any of claims 1 to 13.

25

26. A signal carrying processor-implementable

instructions for controlling a processor to carry out the method of any of claims 1 to 13.

27. A mobile station for a cellular communications system, wherein the mobile station is adapted to determine a quality of service level as a communication route to it is extended and is further adapted to request a replacement communication route if the quality of service level falls below a required level.

10

28. A method of routing a mobile station in a packet switched network arrangement substantially as hereinbefore described with reference to the accompanying drawings.

15

29. An apparatus for routing to a mobile station in a packet switched network arrangement substantially as hereinbefore described with reference to the accompanying drawings.



Application No: GB 9930439.6
Claims searched: 1 to 29

27

Examiner: Glyn Hughes
Date of search: 22 June 2000

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:
UK Cl (Ed.R): H4L (LDGP, LDGX), H4K (KMG, KPT)
Int Cl (Ed.7): H04L 12/56, H04Q 7/22
Other: Online: EPODOC, WPI, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
	NONE	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.